THE EFFECTS OF TWO TYPES OF TESTING MATERIALS AND SEQUENCES ON THE PERFORMANCE OF A PIAGETIAN TEST FOR THE CONSERVATION OF LIQUID

by
Elizabeth WONG Kuk-Ue

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WONG KUK-UE

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THESIS COMMITTEE

(Chairman)

SHIU L. KONG

WILLIAM F. DUKES

JOSEPH KATZ

BIOGRAPHICAL NOTE

Elizabeth WONG Kuk-Ue (黃菊如) was born in China on the 3rd August, 1938. She received her education in Hong Kong, and obtained her Bachelor of Arts degree from the University of Hong Kong with honours, in 1963. She taught at St. Luke's Co-ed. College, Hong Kong, for three years, and also served as administrative assistant to the principal of the same school. She took a postgraduate course in languages at the University of Geneva, Switzerland, in 1965. She was married to a Paediatrician, in London, later in that year. Upon her return to Hong Kong, she established St. Nicholas' Nursery School and Kindergarten in 1971. At present, she is the mother of three children as well as the Headmistress of the school, which has an enrolment of 150 children of different nationalities.

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CHAPTER ONE

PROBLEM

Since the publication of Piaget's theories on children's cognitive development, a large number of studies have been conducted on the theme of the child's developmental abilities in handling concepts of conservation. Some of these studies were conducted by Piaget and his colleagues at Geneva, others by researchers in various countries around the world.

In recent years, Piaget and his colleagues at Geneva have developed more sophisticated and better-controlled experiments to test their original theories, and to explore new dimensions of cognitive development. At the same time, the number of cross-cultural studies aimed at validating Piaget's findings by replicating his early experiments is on the increase. An equally large number of researchers have concerned themselves with problems generated by Piaget's theories, but not directly related to them. As a whole these studies have investigated a wide range of problems relative to the now well-known "Piagetian Controversy". The present author found the following four questions, together with research findings around them to be most interesting.

First, whether children of different cultures progress similarly or differently through the stages of cognitive development as described by Piaget (Slater, 1958; Hyde, 1959; Lovell, 1960; Dodwell, 1960; Elkind, 1961; Smedslund, 1961; Noro, 1961; Lawrence, 1963). Second, how is attainment of a particular level of thought in the Piagetian model related to progress in intellectual development as seen in other models? (Farnham-Diggory, 1972). Third, to what extent is progress from one level of thought to various kinds of experience, or, can training accelerate the transition? (Churchill, 1958; Wohlwill, 1960; Smedslund, 1961 (a, b, c, d, e, f); Inhelder & Sinclair, 1969). Fourth, can different testing procedures or situations, including special questioning techniques elicit different information about children's pattern of cognitive development? (Carpenter, 1955; Mannix, 1960; Laurendeau & Pinard, 1962; Beilin, 1962; Bruner, 1964; Brison, 1964; Almy et al, 1966; Sullivan, 1967).

Problem Statement

Specially, this study purports to investigate the following two problems:

1. To find out the critical age when Chinese children of a selected kindergarten in Hong Kong begin to master the concept of the conservation of liquid, and to compare the results with those obtained from other cultures in research findings.

2. To find out if children of the same age and background differ in the ability to handle the concept of conservation of liquid when tested in two different situations, one replicating Piaget's original test method and materials which are novel to the children: the other using the same method with materials that are most familiar to them.

Related Literature

Within Piaget's theory of cognitive development, perhaps the most interesting and controversial topic is conservation. In his Logic and Psychology (1953), Piaget pointed out that in cognitive development, human beings go through four main stages which extend from birth to maturity: the sensori-motor stage (0 to 2 years), the pre-operational stage (from 2 to 7 years), the concrete-operational stage (7 to 11 years), and the formal-operational stage (11 to 16 years). In this sequence the first two stages were considered to be the prelude to the latter operational stages when the adolescent began to master abstract and free thought. From the psychological point of view the criterion for the appearance of such "operational thought" is the child's ability to construct invariants in things and phenomena around him, or his acquisition of concepts of conservation. Piaget regarded the appearance of such a system of operational thought as the first clear conquests of intelligence; and through a series of experiments, demonstrated that somewhere

between the ages of 7 and 8, the average child is able to handle concepts of conservation in such things as number, substance, liquid, area, and volume (Piaget, 1953).

Because of the significant implications of Piaget's theory, and particularly because of his general claim of the universality of his stages of development, many researchers found it interesting to find out whether in fact children growing up in different cultures do go through these same stages in the same way as Swiss children in Geneva do. Some of these interests centred particularly on how children in various countries of the world develop concepts of conservation. For example, Hyde (1959) attempted to validate Piaget's original experiments on conservation of number with a multi-racial group of children in Aden. The subjects were composed of European, Arabic, Indian and Somali children. The results of this study confirmed the findings by Piaget. However, Hyde discovered that there was a difference of one to two years at which his European and non-European children began to conserve: in many tests, fewer than half of the non-European children had achieved an operational level at the age of 8, when by comparison, more than half of the European children had achieved that level at the age of 7 or even 6. In discussing his results, Hyde pointed out the possible reason behind this age difference is the varied family-backgrounds of his subjects. Since the European children were considered to be socially and economically above the

non-European children, Hyde contended that there was clear evidence of the influence of cultural factors on the development of operational reasoning. Slater (1958) working with English children demonstrated similar results, i.e. children whose environment was more stimulating tended to conserve numbers earlier than their less fortunate counterparts.

Using Canadian children as subjects, Elkind repeated a number of Piaget's experiments related to the conservation of quantity. In one study, he tested children from four to seven years of age with sticks, beads, and liquid. He came up with the conclusion that success in comparing quantities increased significantly with age; and that conservation of liquid was the most difficult among the tasks involved. In another study, Elkind (1961a) tested children from kindergarten through the sixth grade for their abilities in conserving mass, weight, and volume. The results approximated Piaget's findings that conservation of "substance appears at around the age of seven, weight nine to ten, and volume eleven or twelve" (Logic and Psychology, 1953).

Similar studies confirming Piaget's findings were reported using Japanese children (Noro, 1961) and New Zealand children (Lawrence, 1963) as subjects.

Among studies validating Piaget's findings on the development of the concept of conservation, interest soon shifted from merely investigating the critical age at which

children of varying backgrounds begin to conserve to investigating the conditions under which children conserve or do not conserve. Invariably, researchers found in their analysis of results new evidence that children do not just conserve because of age, rather the quality of one's experience has definite effects on one's age of conservation. On the other hand, new interests or doubts were generated on whether conservation is a stable psychological construct or whether it is the result of a definite testing method or situation; in other words, whether different testing situations produce different results.

Thus, attempts were made to examine conservation not as one stage of cognitive development, but as a process of finer steps or stages of thought. For example, in their study of the global quantity conservation in seven to ten-year-old children in an English junior school, Lovell and Ogilvie (1960) made an intensive analysis of their findings in terms of three sub-stages of operation, namely: non-conservation, intuitive and unreliable conservation, and operational conservation. They reported that their children's performance varied from one stage to another owing to the nature of the situation, and that children at the intermediate sub-stage often learned to understand the concept of conservation in the course of the experiment. This seemed to suggest that given the right stimulus children who seemingly do not conserve might be able to perform their tasks correctly. In

a subsequent study, Lovell and Ogilvie (1961) found that most of the children who conserved weight could perform the logical operation of transitivity in relation to weight, but for unspecified reasons many non-conservers could also do the same.

On the other hand, Smedslund (1961b), working on the same topic with Norwegian children ranging in age from five years and six months to seven years, and using a technique that offered each child four different testing situations on conservation, also asked the subjects to perform the transitivity operation. His results differed strikingly from those of Lovell and Ogilvie in that he found little association between the children's ability to conserve and their ability to recognize transitivity.

Working with Canadian children, Dodwell (1960) replicated five of Piaget's experiments with five to ten-year-olds. The results of the tests involving conservation showed marked variations from task to task. Eighty per cent of the children showed operational thinking at the age of five years and ten months when dealing with the eggs and egg cups, and 80 per cent conserved in the experiment with the beads, but none of the children of that age could conserve with the chips. In the same study results of the tests of seriation and cardination-ordination showed even less clear age trends than the conservation tasks. In a later reanalysis of the data, Dodwell (1961) noted that there were other factors

affecting the results other than the difficulty of the tasks, therefore he concluded that "the pattern of development of number concepts did not follow the sequence as described by Piaget with great regularity."

What are some of the possible factors that affect children's ability to handle conservation tasks? Can conservation be taught? Or is conservation guided by perceptual "intuitions" as Lunzer (1960) hypothesized? On the other hand, the effect of environment as a whole influencing the early appearance of conservation in children was suggested, which, in turn, generated a number of experiments testing the effect of teaching, and the use of testing sequence as teaching clues on conservation test results. For example, Churchill (1958) had designed her study to probe the applicability of Piaget's theoretical formulations to educational practice. Sixteen five-year-olds, who had been matched for their understanding of number concepts, were divided into two groups. One of these groups was then given a special programme of number experiences over a period of four weeks. In this programme, the children were given suitable assortments of toys and shapes, and they were encouraged to discover for themselves the invariance of numerical relations. The other group which served as a control group were not given any special training. At the end of the treatment period, both groups were given another set of tests. The experimental or enriched experience group was found to have made a significant

improvement as compared with the control group; and the relative superiority of its members was maintained on retesting three months later. This study had led Churchill to believe that environment, and especially designed learning experience, can do a great deal to accelerate the progress of children in their understanding of number. However, she was careful to point out that the reverse effect may be achieved by premature training in mechanical sums.

Wohlwill (1960) came up with a different conclusion after he had taught his subjects adding and subtracting in relation to the conservation of number. He found it difficult or impossible to design experiences that would shift a child who was at the height of a perceptually dominated stage to operational reasoning. Smedslund (1961c) tested two groups of children, one of which had been "taught" to conserve weight, while the other knew how to conserve at the time the study began. Results showed that those children who had "supposedly learned" to conserve weight reverted to non-conservation when the testing situation changed. He therefore confirmed Piaget's notion that the concept of conservation has to be spontaneously constructed by the child himself.

On the other hand, Almy et al (1966) observed in their study that the ordering of success in the tasks of conservation of number was dependent on the children's experience with counting. In a similar view, Inhelder and Sinclair (1969) trained children to conserve quantity with

specially designed apparatus. They were able to succeed in producing some improvement in pre-operational thinking with children who were about to outgrow the pre-operational thinking stage. In addition, Siegel, Roeper, and Hooper (1966) reported a pilot research in which they concluded that training programmes focusing on prerequisites for relevant cognitive operations influence of the resultant cognitive structures of their subjects.

Generally speaking, experiments attempting to accelerate the understanding of conservation by means of training did not produce uniform results. Therefore one is led to consider the effectiveness of the testing techniques used in various testing situations.

According to Mannix (1960), Piaget himself had emphasized the role of compensatory differences in a test situation, e.g. in a task of conservation of number, the intervals between items in a row and the length of the row would affect the child's ability to conserve. As reported by Bruner (1964) when one of his associates introduced a screen to keep off his subjects' biased perceptual experience when replicating Piaget's test of the conservation of liquid he was able to improve his subjects' scores in conservation. In another study along the same line, Brison (1964) used orange juice as testing material to replace water. His results supported his conjecture that children might be able to conserve earlier if properly motivated. In addition to

this, it was observed by Laurendeau and Pinard (1962) that some techniques of questioning were better suited than others in bringing out the real thought of the child. Even language might serve as a kind of prop to help the child to overcome the pull of visual perception, and, as it was suspected by Beilin (1962) the child's inadequacy in language might have caused him to lose the grasp of logical judgment of quantity and size.

Considering the findings as revealed in the above studies, it became obvious that two areas require further investigation. First, the critical age at which Chinese children begin to conserve liquid needs to be established so that comparison may be made with children in other countries. A complete knowledge on the relative age at which children from varied backgrounds and cultures begin to conserve would help us understand how they compare with each other, and more important, provide the basis for investigation into factors relating to conservation. Second, whether varied test situations would bring out different responses needs to be explored.

Hypotheses

In the present study the following hypotheses were tested:

1. There is no significant difference between the scores obtained from two types of testing materials (orange

juice in beakers of different sizes and Green Spot in bottle and drinking glass) on the conservation of liquid.

2. There is no significant difference between the effects of two sets of testing sequence on the conservation of liquid, i.e. 1. proceeding from Original Test (OT) to New Test (NT), and 2. proceeding from NT to OT.

3. Within each set of testing sequence, there is no significant difference between the proportion of correct and incorrect responses by the children of each different age level.

In addition to these hypotheses, this study also involves in estimating the critical age when Chinese children in Hong Kong begin to conserve liquid.

Definition

Concept of Conservation: According to Richmond (1970), "Conservation could be defined as an operational process of the mind which produces the realization that certain aspects of a changing condition are invariant, despite those changes." In extending his explanation, he also quoted Piaget (Logic, p.9, 1953) that "Conservation has thus to be conceived as the resultant of operational reversibility."

Operationally, conservation is measured by the two tests employed. These tests are described in the section on instruments, Chapter II. A child is considered to be able to conserve liquid when he has responded correctly to the

tasks set forth in the tests.

CHAPTER TWO

METHOD

Research Design

This experiment is a comparative study to investigate the effects of different materials, and varying testing sequence upon conservation concept in young children.

A sample of 84 children attending kindergarten in Hong Kong was assigned at random into two groups for two different tests. One group was given Piaget's Original Test (O.T.), then the New Test (N.T.) while the other group was given the same tests but in a reverse order. The material effects was determined by comparing the group results on the two tests given first in each group. The sequence effect was assessed by cross-comparison between groups on results from the same testing method. The comparison among children grouped on the basis of all age levels will reveal the developmental characteristics as affected by the two measuring situations.

The grouping and treatment design is given in Table 1.

The independent variables were the testing situations which included different materials used, different testing sequence; and age is the blocking variable.

Table 1

The Design for this Study

Test Sequence	Age levels			
	Three	Four	Five	Six
Group A				
1st. Original Test				
2nd. New Test				
Group B				
1st. New Test				
2nd. Original Test				

The dependent variable was the obtained scores from each individual subject.

The intervening variables such as previous educational experience, socio-economic status and so on, were assumed to be controlled by having the subjects assigned into either group randomly.

Sampling

The subjects consisted of boys and girls from a private kindergarten in Kowloon, Hong Kong. The school was located in an upper-middle class residential area. Most of the children came from the neighbourhood. It was a bilingual school with a team of Chinese and English teachers working together. A three-year-programme was offered to the children

in preparing them for junior schools' entrance examinations at the age of six. Apart from the essential kindergarten activities, the children were expected to learn to read and write both English and Chinese (spelling and dictation up to 300 words in each language). In mathematics they were taught sums up to two digits involving carrying.

The sample size is 84 which was made up of children ranging in age from three years 2 months to six years 4 months.

Children belonging to these age levels were chosen because: they were in the pre-operational stage but not too close to the suggested ages of seven to eight when they begin to master the concept of the conservation of liquid. Nursery school in Hong Kong begins at the age of three. It seems easier to get a more homogenous sample from children of a school in terms of their family and educational backgrounds.

In order to find out the effects of two testing situations on conservation, the sample was divided into two groups for treatment and comparison. This was done by means of a stratified randomization process in which children of each age group were pricked randomly and alternately assigned to groups A and B, so that each group had 42 children with an equal number from each of the four age levels.

Instruments

1. For the Original Test (O.T.) of conservation of liquid by Piaget the following were used: Two glasses of

diameter 1⅞ inches x height 2⅝ inches; and a tall-narrow glass of diameter 1⅝ inches x height 4¾ inches, were used as containers of the liquid; some reconstituted orange-juice contained in a large glass pitcher (Appendix 1).

2. For the New Test (N.T.) the following were used: Dozens of Green Spot (a popular orange drink) in their original bottles; an ordinary drinking glass (2½ inches x 4 inches) big enough to hold the content of a bottle of Green Spot; and a bottle-opener (Appendix 2). The Green Spot was chosen as testing material because it was hypothesized that children normally develop concepts of quantity and its invariability through operational experience. In Hong Kong, Green Spot has been frequently advertised as a favourite pop drink for the local children, it is assumed that most of the subjects under test had had a lot of experience of drinking Green Spot. Thus, presumably, they would recognize that the amount of liquid remained the same after the contents of a bottle of Green Spot had been poured into a container of a different shape and looked different.

3. Special scoring sheets for recording the children's performance in this study were prepared (see Appendix 3).

Procedures

The experiment took place during the last week of February, 1975, in the mornings from ten o'clock to half-past eleven during the children's free play period.

The children were interviewed one by one in a small carpeted room with a large mirror on the wall. A long low table was placed in front of the mirror. Two low chairs of equal height were placed side by side on one side of the table where both tester and testee sat.

The investigator being the Headmistress of the kindergarten concerned was able to have good communication with the subjects. To ensure consistency in scoring, the interviews were conducted entirely by herself. One teacher was there to help in rounding up the children for the interviews.

All subjects were given the two tests O.T. and N.T. during one interview. Group A subjects were tested with O.T. first and then N.T., while for group B, N.T. was given first followed by O.T. The tests normally took ten to twelve minutes to complete but the subjects were not given any time pressure for completion.

The tests, like games, were structured as described below and were administered in Cantonese, the children's mother tongue.

Each subject was given an invitation card bearing his name and was told that he was invited to a Tea Party by the Headmistress. When the subject entered the specially prepared room, he was told to sit beside the investigator on the same side of the table. On the table there were two small glasses and a large glass pitcher with reconstituted orange

juice.

1. Investigator: "Let's pretend we are at a party and we have orange juice to drink."

2. She pointed at the small glasses and continued: "Here is a glass for you, and this is for me. Do you think our glasses are of the same size?"

3. Only when the subject responded in the affirmative would the test go on.

4. While the subject watched, the investigator poured the orange juice from the pitcher into the glasses very carefully until the juice reached the brims.

5. She asked again: "Look at your glass and mine, do you think we have the same amount of orange juice to drink?" When the answer was affirmative, the test went on.

6. Then she introduced the tall-narrow glass and asked the subject if he would like to drink from it (he did).

7. She then poured the orange juice from the subject's glass into the tall-narrow glass. She asked: "Now, this is your orange juice (pointing at the tall-narrow glass), and this is mine (pointing at the glass in front of her). Do you think we have the same amount of orange juice to drink, or do you have more to drink, or do I have more to drink?"

8. At this point the subject's response was scored. If the response was correct, showing conservation, i.e. that there was the same amount of orange juice to drink, the subject would be given a score of 1. All failures were

scored zero.

9. After the scoring the subject was offered the drink. Then the apparatus was put away.

The investigator then proceeded with the second test:

1. The investigator took out two bottles of Green Spot, making sure that levels of the juice from the two bottles were the same. She asked: "Do these two bottles of Green Spot contain the same amount of orange juice?" Only when the answer was positive would she proceed with the test.

2. She took out the bottle-opener and a drinking glass saying: "It is not nice to drink from the bottle. I'll pour the orange juice into this glass for you." She opened the bottle and emptied the content into the glass saying: "Here is your drink (pointing to the glass), and here is mine (pointing to the bottle).

3. The Green Spot bottle being narrow and tall would have its content appear in a higher level. The subject was then told to compare the quantity of juice in the original bottle and in the glass.

4. Investigator: "Now do you think we have the same amount of orange juice to drink, or do you have more to drink, or do I have more to drink?"

5. At this point the subject's response was noted and the scoring done in the same way as in the previous test.

For Group B subjects, the procedure was exactly the same except the sequence of the two tests was reversed.

Data Analysis

To test the three hypotheses of this study, the following statistics were employed:

1. The Binomial Test was used to estimate the proportion of correct and incorrect responses in each age level under a specific testing situation.

2. Chi-square technique was used to calculate the group difference caused by the Material Variable which was presumably incorporated in the two different tests given initially between the two groups.

3. Chi-square technique was used to calculate the difference between groups on the same type of tests but in different sequential order.

4. Fisher Exact Probability Test was used to calculate the difference between the proportion of correct and incorrect responses caused by the age variable.

The statistical results together with observations made during testing were then discussed in the light of other research findings and Piaget's theory on conservation. Further analysis was made considering the personal characteristics of individual subjects.

CHAPTER THREE

RESULTS AND DISCUSSION

Table 2 presents the correct and incorrect responses of groups of three-, four-, five-, and six-year-old children on Piaget's original test of the conservation of liquid (O.T.).

As can be seen, there is no one clear-cut age at which children begin to conserve liquid, because there is a certain percentage in each age group (except at the three-year-old level) who responded to the test correctly and the remainder incorrectly. However, there is evidence that beginning at age five, approximately one third of the children tested demonstrated their ability to conserve. At the age of six, over seventy per cent of the children tested had correct responses.

In view of the small size of the sample, the Binomial Test (Siegel, 1956, p.250) was applied to test the significance of the differences between the proportion of correct and incorrect responses in each age level. In all cases the differences between correct and incorrect responses in each age level were not statistically significant despite the relatively large difference observed in the six-year-old group. It should be pointed out that given an opportunity

Table 2

The Performance of Three-, Four-, Five-, and Six-year-old Children on Piaget's Original Test of the Conservation of Liquid

	Age							
	Three N=13		Four N=14		Five N=9		Six N=7	
Performance	f	%	f	%	f	%	f	%
Correct	0	0	1	7.1	3	33.3	5	71.4
Incorrect	13	100	13	92.9	6	66.6	2	28.6

Key: f = frequency

% = percentage

to test a larger sample, the same relative result might be observed and the difference would be statistically significant. A subsequent study using a larger sample may establish the critical age when children in Hong Kong begin to conserve liquid using Piaget's original test.

Table 3 presents the correct and incorrect responses of groups of three-, four-, five-, and six-year-old children on the New Test of the conservation of liquid (N.T.).

From the data shown in Table 3, there is evidence that the five-, and six-year-old children had demonstrated their mastery of the concept of the conservation of liquid. As none of the five- and six-year-old group had failed to respond to the test correctly, it could be assumed that five is the critical age at which Chinese children attending kindergarten in Hong Kong begin to conserve liquid in this specific testing situation.

In comparing the results of the two testing situations, i.e. Piaget's Original Test (O.T.), using orange juice in glasses, and the New Test (N.T.), using Green Spot which is a favourite pop drink for the children under investigation, it is evident that when tested with materials that are more familiar to them, children were able to conserve liquid at least one year earlier than their counterparts who were tested with unfamiliar and novel materials and instruments.

The first null hypothesis states that there is no significant difference between the scores obtained from the

Table 3

The Performance of Three-, Four-, Five, and Six-year-old Children on The New Test of the Conservation of Liquid

	Age							
	Three N=11		Four N=14		Five N=12		Six N=4	
Performance	f	%	f	%	f	%	f	%
Correct	4	36.3	8	57.1	12	100	4	100
Incorrect	7	63.7	6	42.9	0	0	0	0

Key: f = frequency

% = percentage

two types of testing materials (orange juice in glasses, and Green Spot in bottle and drinking glass) for the conservation of liquid.

The Chi-square test was used to compare the scores obtained by Groups A and B which were treated with O.T. and N.T. respectively. Table 4 presents the X^2 results of this comparison. It is evident that the two types of testing materials elicited significantly different results from the sample of children, and it is clear that the group which was tested with N.T. had a significantly larger number of children having correct responses. The difference was significant at the .001 level. The null hypothesis is accordingly rejected.

The second hypothesis states that there is no significant difference between the effects of the two sets of testing sequence on the conservation of liquid. To test this hypothesis, Group A was treated with a testing sequence which proceeded from O.T. to N.T., and Group B proceeded from N.T. to O.T.

Table 5 presents the test results of Groups A and B on the two tests in different sequence. In order to test the effects of this two sets of testing sequence, O.T. and N.T. in Table 5 were collapsed and the results presented in Table 6. The X^2 value is computed (Table 6) which indicates that there is a significant difference at the .05 level. This means that the sequence of the tests have produced different effects on the test results.

Table 4

Comparison of the Results Obtained by Groups A and B on O.T. and N.T. Respectively

Results	Group A (O.T.) N=43	Group B (N.T.) N=41
Correct	9	28
Incorrect	34	13
X^2	19.10*	

* significant at .001 level

Table 5

Test Results Obtained by Group A
and Group B on O.T. and N.T. in different Sequence

Tests	Responses	Group A N=43	Group B N=41
O.T.	Correct	9	18
	Incorrect	34	23
N.T.	Correct	24	28
	Incorrect	19	13

Table 6

Relationship Between Test Sequences and Responses

Responses	Sequence 1 (O.T. to N.T.)	Sequence 2 (N.T. to O.T.)
Correct	33	46
Incorrect	53	36
X^2	4.606*	

* significant at the .05 level

In order to find out the specific effects of the two sets of testing sequence, i.e. to see which of the two tests administered first had a facilitating effect on the tests administered after them, further comparisons were made between the results of Group A and Group B on O.T. and N.T. respectively. In both cases, the results from the same testing materials were compared, i.e. O.T. using orange juice in glasses, and N.T. using Green Spot in bottle and drinking glass. However, in the first comparison O.T. was administered to Group A without any prior test, but to Group B it was administered with N.T. preceding it. In the second comparison, N.T. was administered to Group B without any prior test, but to Group A it was preceded by O.T.

Tables 7 and 8 present the X^2 results of these two comparisons respectively. As can be seen, it seems evident that within the two sets of testing sequence, O.T. did not cause any significant effect on the results of the N.T. administered after it (Table 8). On the contrary, the N.T. did produce a facilitating effect on the results of the O.T. administered after it (Table 7).

The third hypothesis states that within each set of testing sequence there is no significant difference between the proportion of correct and incorrect responses by the three-, four-, five-, and six-year-old groups. In order to test this hypothesis, the Fisher Exact Probability Test (Siegel, 1956, p.256) was employed to compare the scores

Table 7

Effects of N.T. on O.T.

O.T. Results	Group A (No Pre-test) N=43	Group B (preceded by N.T.) N=41
Correct	9	18
Incorrect	34	23
X^2	5.078*	

* significant at the .05 level

Table 8

Effects of O.T. on N.T.

N.T. Results	Group A (preceded by O.T.) N=43	Group B (No Pre-test) N=41
Correct	24	28
Incorrect	19	13
X^2	1.386*	

* Not significant

obtained by each of the age groups so as to set the within group difference caused by the age variable. The reason for using this test was that the scores obtained in some cells were rather small. In a few cases there were even zero scores.

Table 9 presents the results of the Fisher Test comparing the differences of performance on O.T. among the three-, four-, five-, and six-year-old groups. As can be seen, there were significant differences between the six-year-old group and the three-year-old group at the .005 level, and between the six-year-old group and the four-year-old group at the .01 level. The differences among the remaining age groups were not found to be statistically significant.

Table 10 presents the results of the Fisher Test comparing the performance on N.T. among the three-, four-, five-, and six-year-old groups. As can be seen the differences of the scores between the age groups of five and three, five and four, and six and three were significant while the remaining observed differences were not found to be statistically significant. It is noted that while the differences between the three-year-old group and the five-, and six-year-old groups were both found to be significant, the differences between the first pair of groups (three and five) were at a higher level of significance than of the latter pair (three and six). Normally the reverse should have been true since developmentally there should be a greater difference between the six-year-olds and the three-year-olds than between the

Table 9

Matrix Showing the Significant Levels of Age Differences on the O.T.

Age	Age			
	Three	Four	Five	Six
Three	-	N.S.	N.S.	.005
Four	-	-	N.S.	.01
Five	-	-	-	N.S.

Table 10

Matrix Showing the Significant Levels of Age Differences on the N.T.

Age	Age			
	Three	Four	Five	Six
Three	-	N.S.	.005	.05
Four	-	-	.025	N.S.
Five	-	-	-	N.S.

five-year-olds and the three-year-olds. To explain this phenomenon, it is observed that while both of the five- and six-year-old groups had full scores on the test (see Table 3), the six-year-old group had a much smaller sample, thus, statistically its differences would be less probable to be found significant.

In reviewing the findings of the present study, a number of points need to be singled out for discussion.

This study started with an attempt to establish a critical age at which Chinese children attending kindergarten in Hong Kong begin to master the concept of the conservation of liquid; and to compare it with findings based on studies of children in other cultures. It became apparent that the critical age at which children begin to conserve liquid depends very much on the nature of the test used (Tables 2 and 3). In fact younger children are able to conserve the quantity of liquid despite its change of shape when poured into different containers if the situation of transformation is familiar to them. In the present study it was shown that children could conserve liquid at the age of five when tested with N.T. which involved the use of a bottle of Green Spot and a drinking glass. They were able to generally recognize that the amount of pop drink remained the same when transferred from the bottle into a drinking glass with a different shape. When asked why they thought the pop drink in the two different shaped containers had the same amount, the normal answer was

that they had drunk the Green Spot in a glass before. This author's interpretation is that when asked to make the judgment in this situation the children did not so much base their judgment on their visual perception (Lunzer, 1960) as on their actual experience of drinking Green Spots, i.e. they have always felt that it was the same amount whether they drank it from the bottle or from the glass.

This observation, if it could be further substantiated may have important implications on the evaluation and interpretation of conservation abilities, as well as on teaching for cognitive development. Within Piaget's theory, the reason why children at the preoperational stage fail to conserve liquid is that of their centration characteristics which limit them to focus their attention on a simple dimension of an object or event instead of observing it as a whole. It is not until they have reached the age of seven or so that children begin to decenter their perception, thus striking a balance (and therefore conservation) view about things (Piaget, 1950). According to this study, there is some evidence that children in the preoperational stage may not rely on perceptual clues for their reasoning. They may, as in the case of the testing with Green Spot, rely on other direct clues as the basis for their reasoning. In this case because Green Spot is a popular drink for the children, and that they may have the experience of drinking it directly from the bottle as well as from the glass before; and they may have felt that the amount

of orange drink remains constant in both cases, the author's conjecture is that, because of this direct experience in operation, even some of the four-year-old children were able to recognize the constancy of the amount of Greeen Spot in the two containers. It would be interesting to test this conjecture in a subsequent study using a larger sample. If the conjecture is proved to be correct, then we might have to review our method of conservation testing.

From the analysis of the effects of the two testing sequences (Tables 7 and 8), it appears that N.T. had a facilitating effect on O.T. results when the latter was administered after the former. Because children tested generally showed that they could conserve one or two years earlier when tested with N.T. than when tested with O.T., it is appropriate to suggest that conservation abilities might be taught or elicited through the use of familiar objects or through relating relevant experiences to new cognitive activities. This is in agreement with findings of other studies which suggested that the cultural background and special quality of the experience of a child may influence the onset of his conservation abilities (Hyde, 1959; Slater, 1958; Almy et al, 1966). In a different dimension studies have also shown that children's understanding of conservation varied from task to task in accordance with different testing situations or materials (Dodwell, 1960; Lovell and Ogilvie, 1960; Smedslund, 1961b; Bruner, 1964; Brison, 1964). Even

the language used for testing was found to be a factor affecting children's performance in conservation tests (Laurendeau and Pinard, 1962; Beilin, 1962). In fact, successful attempts were made to train children to understand concepts of conservation under experimental situations (Churchill, 1958) and, in recent years, the role of training in helping children to acquire conservation abilities early was recognized and tested in Piaget's own centre (Inhelder and Sinclair, 1969). The identification of specific factors influencing children's developmental process on conservation and the design of effective programs to help children develop their cognitive abilities more efficiently remain to be insistent tasks for psychologists and educators.

CHAPTER FOUR

SUMMARY AND RECOMMENDATIONS

This study was designed to find out (1) the critical age when Chinese children attending kindergarten in Hong Kong begin to master the concept of the conservation of liquid; and (2) if children of the same age and background differ in their performances when tested with two conservation tests, one replicating Piaget's original test on liquid conservation, the other follows the same method by using materials that are more familiar to the children. Quantitative analysis were also made on the observations made during the testing processes.

In order to achieve the objective of this study a new test was constructed following Piaget's original test for the conservation of liquid, but with the use of Green Spot and an ordinary drinking glass. These materials were chosen in view of the findings of a number of studies indicating that children's performance on conservation tests varies from task to task and from situation to situation. It was thought that the use of familiar materials in a test would facilitate children's performance in a given task.

In the main, three null hypotheses were tested:

1. There is no significant difference between the

scores obtained from two types of testing materials (orange juice in glass, and orange drink in bottles) on the conservation of liquid.

2. There is no significant difference between the effects of two sets of testing sequence from Original Test (O.T.) to New Test (N.T.), or vice versa on the conservation of liquid.

3. Within each set of testing sequence there is no significant difference between the proportion of correct and incorrect responses by the children of each different age level.

In addition the critical ages when children begin to conserve liquid were delineated under different testing situations. Detailed observations were also made throughout the entire study utilizing existing theories and research findings in an attempt to understand how children perceive objects and events, as well as how they bring their own experience to bear when asked to solve a single problem presented in different ways.

A sample of 84 children ranging from three to six years of age was assigned at random into two groups for two different treatments. One group was given Piaget's Original Test (O.T.), then the New Test (N.T.) while the other group was given the same tests but in a reverse order. The material effect was determined by comparing the group results on the two tests given first in each group. The sequence effect was

assessed by cross-comparison between groups on results from the same testing method. Comparisons were also made among children grouped on the basis of age levels to reveal the developmental characteristics as affected by the two measuring situations.

The independent variables were the testing situations which included different materials used, different testing sequence; and age level was used as the blocking variable. The dependent variable was the obtained scores from each individual subject.

According to the X^2 comparison, the two types of testing materials O.T. and N.T. elicited significantly different results, and it is clear that the group which was tested with N.T., as a whole had a significantly larger number of children having correct responses. The first null hypothesis is accordingly rejected.

With regard to the second null hypothesis, there was evidence to suggest that when the New Test preceded Piaget's original test, the former created certain facilitating effect on the obtained scores of the latter at the .05 level. Piaget's original test, however, did not cause any significant facilitating effect on the New Test when the latter followed it.

In testing the third hypothesis, there were significant differences in the proportion of correct and incorrect responses between the six-year-old group and the three-year-old group at the .005 level, and between the six-year-old group and the

four-year-old group at the .01 level. The differences among the remaining age groups were not found to be statistically significant.

On the basis of the results, it was found that there is no one clear-cut age at which children begin to conserve liquid, rather the critical age varies with the test used. With Piaget's original test, it seems that the majority of the six-year-olds are able to conserve, but with the new test, the critical age is five. In effect this means that the new test is more readily understood and its task more easily and successfully performed by the children.

To explain this fact, it is conjectured that with materials that the preoperational child does not have too much direct experience, he normally uses perceptual clues as the basis for judging the quantity of liquid. Thus when the shape of a quantity of liquid is changed (such as when poured into a differently shaped container), its quantity is judged as having been altered. However, when presented with materials that are more familiar to him, particularly when he has already had a lot of operational experience on such materials, the preoperational child, although in his centration perception stage, is able to use his own operational clues as the basis for recognizing the constancy of the amount of liquid, even when its shape has been changed. In other words, he is able to conserve liquid.

This is a very interesting finding, because if it

could be proved that children could generally conserve liquid at an earlier age when given the right clue, then we might have to review and modify our method of conservation testing and even our understanding of conservation development. This study has presented some initial evidence that conservation abilities might be "taught" or elicited through the use of familiar materials or through relating relevant experiences to new cognitive activities. Unfortunately, the results were not conclusive because of the relatively small sample used and the lack of specific controls of other possible factors that might also bear on the performance of conservation task. It is recommended that more vigorous research be done to identify the specific factors that influence children's development of concepts of conservation, and to design more effective teaching programs to help children develop their cognitive abilities.

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Scoring Record (Group A)

Name of pupil:

Date of birth: Day Month Year

Sex:

Position in family:

Mother tongue:

Schooling experience:

Scoring:

Piaget's Original Test (O.T.)

Same amount to drink _____

Not the same amount _____

Score _____

Remarks:

New Test (N.T.)

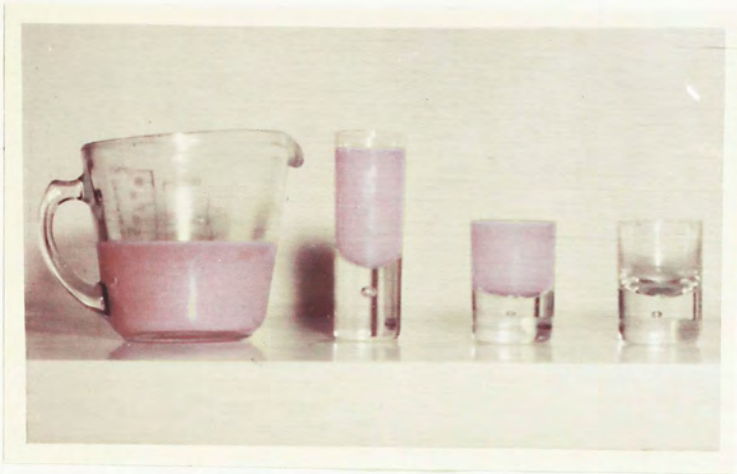
Same amount to drink _____

Not the same amount _____

Score _____

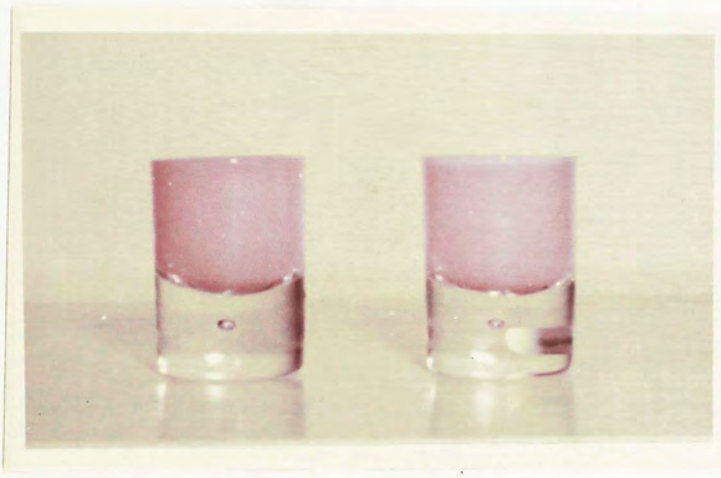
Remarks:

APPENDICE I



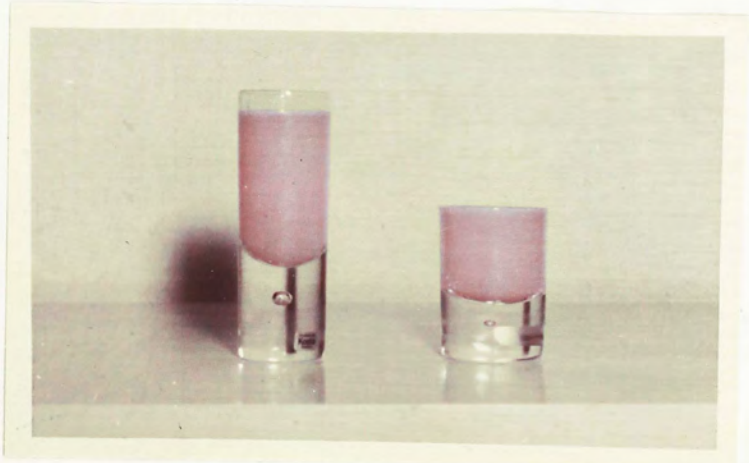
Materials for the Conservation of Liquids

PIAGET'S ORIGINAL TEST (O.T.)



(Start) Same amount

Pour



Still the same?

APPENDICE II

Materials for the Conservation of Liquids

New Test (N.T.)

(Start) Same amount

Pour

Still the Same?